THE WESTERN AUSTRALIAN
NATURALIST

Vol. 22 28th June 1998 No. 1

VERTEBRATE FAUNA OF THE NIFTY MINE SITE, GREAT SANDY DESERT, WITH COMMENTS ON THE IMPACTS OF MINING AND REHABILITATION

By JOHN READ
WMC Resources Ltd. (Olympic Dam Corporation),
PO Box 150, Roxby Downs, S. Aust. 5725.

ABSTRACT

Vertebrate populations were surveyed in the vicinity of the Nifty Copper Mine in the Great Sandy Desert from 1994–1997. A total of 56 reptile, 5 frog, 24 mammal and 91 bird species were recorded, including several species of conservation significance such as the Bilby, Mulgara, Northern Marsupial Mole, Ghost Bat and Grey Falcon. Frogs, particularly *Notaden nichollsi*, were very abundant and did not exhibit higher levels of skeletal abnormalities in the vicinity of the mine compared to remote sites. Fauna recolonisation of rehabilitating waste dumps was rapid, particularly for *Mus musculus*, *Smithopsis youngsoni*, *Varanus brevicauda* and *Ctenotus quattuordecimlineatus*. Several waterfowl species and Zebra Finches, Magpie-larks, White-backed Swallows, Fairy Martins, Diamond Doves and Budgerigars benefited from permanent water associated with the mine. Control of feral animal populations and improved fire management are highlighted as being important for maintaining the exceptional biodiversity of the Nifty area.

INTRODUCTION

Nifty Copper Operations (NCO) (121°35'E and 21°40'S) is an open cut copper mine with acid heap-leach pads and electrowinning processing plant approximately 70km west of Telfer in Western Australia. (Fig. 1). The Nifty mine is situated amongst dunefields near the south-western margin of

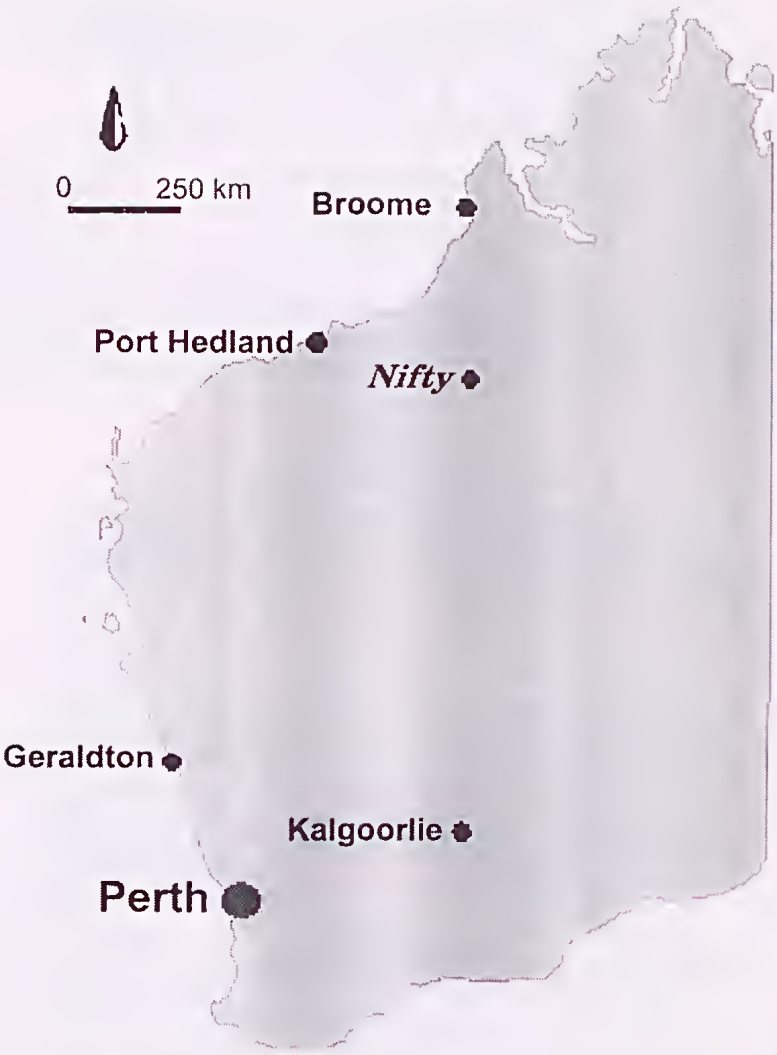

Figure 1. Location of Nifty

the Great Sandy Desert. The sand-dunes are generally oriented from south-east to north-west and reach heights of 18m above the adjacent sandy or clay swales. The principal vegetation in the swales is *Triodia basedowii* which is replaced by *Plectrachne schinzii* on dunes and deep sand. Several *Eucalyptus*, *Acacia* and *Grevillea* species form a sparse overstory in some areas and *Melaleuca*, *Thryptomene maissoneuvei*, *Calytrix carinata*, *Acacia ancistrocarpa* and *A. translucens* form localised dense shrub cover (Hart, Simpson and Associates 1992). Drainage is largely endoreic, with water

collecting in low-lying regions vegetated largely by *Melalueca glomerata* and *Eucalyptus coolabah*.

The Nifty mine is located in one of the hottest regions of Australia with daily maximum shade temperatures consistently exceeding 40°C and occasionally reaching 50°C at the mine meteorological station during the summer months. The average annual rainfall of 315mm, originates primarily from cyclonic rain depressions occurring from December to March. The rainfall is extremely variable with single rainfall events sometimes exceeding the annual average.

The mine is managed on a fly in/fly out basis with the entire workforce of approximately 100 housed in camp accommodation. No pets are allowed and feral cats and foxes are discouraged by diligent environmental hygiene and daily burial of rubbish in the mine waste-rock dumps. With the exception of the open pit, leach pads and processing plant which together occupy approximately 70ha, these overburden and waste-rock dumps are the principal environmental disturbance on site. Waste-rock dumps are modelled to blend with and resemble local landforms and the walls are battered off to a slope of 20°. Revegetation of these dumps proceeds rapidly following spreading of topsoil. *Triodia basedowii* is the principal early coloniser and is gradually replaced by a succession of *Acacias*, *Grevilleas* and other shrubs. Areas rehabilitated in November 1993 already had a vegetation cover and species diversity exceeding that of neighbouring control sites by June 1995 (Nifty Copper Operations 1995).

A series of fauna surveys were conducted at Nifty in order to: identify any rare or regionally significant vertebrates or habitats; determine any impacts of the development on local species; and assess the response of the vertebrate fauna populations to waste-rock dump rehabilitation (Read 1994, Read and Moseby 1995, Read and Niejalke 1996).

METHODS

Small terrestrial reptiles, amphibians and mammals were surveyed at nine monitoring sites in the vicinity of NCO in April 1994, October 1995, and March and November 1996. The habitat type and landuse of the trap sites are presented in Table 1. Four pitfall and a minimum of 10 small Elliott traps were set at each site for 5 consecutive nights on each survey. Twenty litre buckets spaced at 8m intervals and linked by flymesh drift fence served as pit traps. Large Elliott traps were set at most sites and at opportunistic locations to survey for medium-sized mammals during the October 1995 survey. Active searches for tracks, scats or burrows were conducted at all sites. Spotlight searching was carried out by vehicle on established tracks throughout the region for 1.5 to 3 hours on at least three nights each survey and by foot at sites where signs of Bilbies were evident. Four sites, with four pits and ten small Elliott traps, on rehabilitating waste dumps were

Table 1. Location, habitat type and landuse of the Nifty vertebrate monitoring sites

Site	Easting	Northing	Habitat	Landuse
1	336624	7601768	*E. coolabah* & *T. basedowii* run-on swale with termite mounds	control
2	350402	7604285	*E. coolabah* & *T. basedowii* run-on swale with termite mounds	mining: adjacent to rehabilitated camp site
3A	350779	7605286	*E. chippendalei* & *P. schinzii* dune crest	mining: 200 m west of waste rock dump
3B	350876	7605489	*Melaleuca* spp. and *T. basedowii* swale	mining: 200 m west of waste rock dump
4A	358624	7601786	*E. chippendalei* & *P. schinzii* dune crest	control
4B	358474	7601968	*T. basedowii* swale, patch-burnt in 1989	control
5	362957	7600080	*P. schinzii* & *T. basedowii* sand plain	control
6R	367415	7600232	*T. basedowii* clay palaeodrainage channel	control
6T	367497	7600119	*T. basedowii* clay palaeodrainage channel with termite mounds	control
R1	351487	7604923	rehabilitation commenced April 1995	mining: rehabilitating waste-rock dump
R2	351601	7604739	rehabilitation commenced 1994	mining: rehabilitating waste-rock dump
R3	351684	7604787	rehabilitation commenced 1994	mining: rehabilitating waste-rock dump
R4	352171	7604517	rehabilitation commenced May 1995	mining: rehabilitating waste-rock dump

surveyed contemporaneously with the aforementioned sites on the latter two surveys.

In addition to pitfall trap capture, frogs were collected opportunistically at night following rain and carefully checked for departures from bilateral symmetry which could indicate skeletal abnormalities. Frogs were returned to their capture location at the conclusion of each sampling session to avoid re-sampling the same individuals.

Three mist-nets were set to catch bats around the sewer ponds and adjacent sand dunes on the nights of 11 and 12 October, 1995 and an Anabat ultrasonic bat detector was operated at two sites for three nights on the two later field trips. Identification of several bat species through sonographs alone was tentative due to the geographic and individual variability in calls of some species (T. Reardon pers. comm.).

Quantitative bird counts were conducted at six sites for one hour during a morning and afternoon on each of the last three surveys. Opportunistic sightings or collections of species by mine staff since the 1994 survey were verified and added to the data base. A trapping session in March 1997, conducted by CALM personnel, used some of the established monitoring sites and established additional sites. Data from this survey have been in-cluded as opportunistic records, to maintain the consistency of the systematically collected site specific data. Voucher specimens of all species not previously verified, with the exception of endangered taxa, were lodged with the Western Australian Museum.

Field work was conducted under CALM licence nos. SF001227, SF001666, SF002001 and SF002002.

RESULTS

Reptiles

A total of 57 reptile species have been recorded from the Nifty region (Table 2). In addition, a ridge-tailed monitor differing from adult *Varanus acanthurus* by its small size and simple dots rather than ocelli on the dorsal surface was collected, which probably represents an undescribed species (K. Aplin pers. comm.). The whip snake collected is similar to *Demansia rufescens* except that it has a nuchal bar and hence probably represents one of the undescribed species in this genus (L. Smith pers. comm.). One Flat-shelled Turtle (*Chelodina steindachneri*) was collected from a road near the minesite and lodged with Western Australian Museum. Since this species is dependent on aquatic habitats it is most likely that this record represents an individual which was transported to the site, rather than an individual straying from the Oakover River, approximately 40km away. However, *C. steindachneri* is remarkably resistant to desiccation and individuals are often found in isolated waterholes which dry for up to 12 months (Cann 1978). Therefore, there is a slight chance that the individual recorded from Nifty was a naturally nomadic individual.

Table 2. Reptiles, amphibians and mammals recorded on NCO fauna surveys until June 1997

Species	Sites													Total
	1	2	3A	3B	4A	4B	5	6R	6T	R1	R2	R3	R4	OPP	
REPTILES															
Geckos															
Diplodactylus conspicillatus						3	2	2	1					4	12
D. jeanae														1	1
D. stenodactylus	1		2	1	4			3		1	4	1		36	53
Gehyra pilbara		1	1						5						7
G. purpurascens		?		?										9	9
Gehyra c.f. punctata														1	1
Heteronotia binoei	1	1	3		1				4						10
Nephrurus laevissimus					1					2			1	10	14
N. levis	+			1								2		15	18
Rhynchoedura ornata		1		1										9	11
Strophurus ciliaris aberrans														2	2
Legless Lizards															
*Delma borea**														1	1
Delma haroldi	1						1								2
Lialis burtonis														2	2
Pygopus nigriceps		1					1			1				10	13
Dragons															
Ctenophorus caudicinctus															5
C. clayi				1											1
C. isolepis	5	5	5	1		3	7	3	4	6	1	1		8	49
C. nuchalis				1										8	9
Diporiphora winneckei			4	1	5	1		1		1				18	31
Gemmatophora longirostris		+			1									4	5
Moloch horridus				+										2	2
Skinks															

Ctenotus ariadne		3	1	1		4		2	2	1	1			2	17
C. brooksi			4		2					1				2	9
C. calurus		2	1	1		2	1							2	9
C. colletti		1	5	3	5		4	1		1		1			21
C. grandis grandis	1	4		4		3	7	3	2					4	28
C. helenae	2								1					2	5
C. leae			2		1										3
*C. nasutus**														1	1
C. pantherinus ocellifer	3	1	2	2	2	3		7	5	1		2		10	38
C. piankai	1	5		3	1	2	4	2				1	2		21
C. quattuordecimlineatus			3	1	5		1			4	2		1	4	21
Egernia striata														1	1
Eremiascincus fasciolatus		1	9	2	13		1			2	1	3		5	37
Lerista bipes	10	17	6	7	10		5	4	4	2	1			7	73
L. ips			5		2										7
L. xanthura			3												3
Menetia greyii	2	4	1	5	3		1	1	1			2		2	22
Notoscincus ornatus					3										3
Tiliqua multifasciata														1	1
Goannas															
Varanus acanthurus	1	1							2						4
V. brevicauda			1	1			2		1	3	2	2	1		13
V. eremius	1	2	1	1	1	2		3	1				2	2	16
V. giganteus														1	1
*V. gilleni**														1	1
V. gouldii	1	1		1		1			1					7	12
Varanus sp.														1	1
Blind Snakes															
Ramphotyphlops grypus						1		1	1		2			1	6
R. endoterus			5	1	3		1							1	11
Ramphotyphlops sp.					1						1				2

Table 2 (cont.)

Species	Sites														Total
	1	2	3A	3B	4A	4B	5	6R	6T	R1	R2	R3	R4	OPP	
Pythons															
Aspidites ramsayi														2	2
A. melanocephalus														1	1
Liasis stimsoni														2	2
Elapid snakes															
Demansia sp. aff. rufescens					1		2							1	4
Pseudonaja nuchalis														3	3
P. modesta											1			2	3
Pseudechis australis														1	1
Simoselaps anomalus					1										1
Tortoises															
Chelodina steindachneri														1	1
FROGS															
Cyclorana maini	1							1						30	32
Litoria rubella														12	12
Neobatrachus aquilonius	1	1						11			1			15	29
Notaden nichollsi	42	13	27	15	7	7	9	67		14	14	8	12	343	578
Uperoleia sp. aff. *russelli*	3	2	5					18			1			20	49
MAMMALS															
Dasyurids															
*Dasykaluta rosamondae**				1										8	9
Dasycercus sp.				0		3								1	4
Ningaui ridei			3	1	4	1	3					1		3	9
Pseudantechinus macdonnellensis	l	1							2					3	8
Planigale maculata	2				1			2	1						6
Sminthopsis youngsoni		2	1			2	5	1		2	1	1		6	12

Rodents															
Notomys alexis		1	3		6	1								4	15
*Pseudomys desertor**														1	1
Pseudomys hermannsburgensis	1	3	8	6	4	6	3	4	1	2	7	5	3	24	77
Mus musculus	1	1								6	9	13	9		39
Bilby															
Macrotis lagotis		+		+				+							+
Marsupial Mole															
Notoryctes caurinus														1	1
Dingo/ Fox															
Canis dingo/Vulpes vulpes	+	+	+	+				+	+	+				2	2
Cat															
Felis catus	+	+	+	+				+		+				1	1
Camel															
Camelus dromedarius	+							+	+						+
Ghost Bat															
Macroderma gigas														1	1
Sheathtailed Bats															
Saccolaimus flaviventris														+	+
Taphozous georgianus/hilli														+	+
Mastiff Bats															
Mormopterus australis														+	+
Vespertilid Bats															
Chalinolobus gouldii														+	+
Scotorepens balstoni														+	+
Scotorepens greyii														+	+
Vespadelus finlaysoni														+	+

Species marked by * recorded by Peter Kendrick (CALM), or Mark Robertson (WMC) and awaiting confirmation by WAM.

Reptile species richness was highest at the swale site 3B, whereas capture rates were highest at the sand dune sites 3A and 4A where subterranean species of *Lerista* and *Eremiascincus fasciolatus* were abundant (Table 1). *Lerista bipes* was the most common reptile captured and did not appear to favour a specific habitat type although it was not recorded at the recently burnt 4B site in the 1994 survey. *Ctenophorus isolepis* and *Eremiascincus fasciolatus* were also common and widespread, with the latter species more common on the dunes. Several species, namely *Ctenotus leae, C. brooksii, Lerista ips, L. xanthura, Notoscincus ornatus, Simoselaps anomalus* and *Ramphotyphlops endoterus* were predominantly recorded at dune sites. By contrast, *Diplodactylus conspicillatus, Ctenotus grandis* and *C. piankai* were largely restricted to swale habitats. *Gehyra pilbara* and *Varanus acanthurus* were usually recorded at sites with termite mounds whilst *Nephrurus* spp., *Ctenous quattuordecimlineatus* and *Varanus brevicauda* were trapped most frequently on rehabilitation sites.

Mammals

Twenty-one native and three introduced species of mammal have been recorded in the Nifty region (Table 2). This figure may increase further if more detailed analyses of bat sonographs can distinguish between different *Nyctophilus* species. In addition, kangaroo tracks have been recorded at several sites which could be attributed to Red Kangaroos (*Macropus rufus)* in open country or Euros (*M. robustus)* near rocky outcrops or ranges. The diversity of carnivorous marsupials is particularly striking with six sympatric genera of dasyurids recorded. The most conservation significant species recorded, the Bilby (*Macrotis lagotis*), Mulgara (*Dasycercus* sp.) and Northern Marsupial Mole (*Notoryctes caurinus*), are all rare and threatened nationally (Maxwell *et al.* 1996). The mole is a recently described species, known only from 6 localities in the Gibson and Great Sandy Deserts, and the Mulgara may represent an undescribed species (Maxwell *et al.* 1996). The Ghost Bat is also considered to be vulnerable (Richards and Hall 1996).

Pseudomys hermannsburgensis, the most common mammal in the Nifty region was widespread through all habitats surveyed, whereas the other common rodent, the Spinifex Hopping Mouse (*Notomys alexis)* favoured dune sites. Capture rates for *Notomys alexis* may not accurately reflect true population density as *Notomys* are rarely caught in shallow pitfalls and Elliott trap captures may depend on food availability. The Wongai Ningaui (*Ningaui ridei)* was recorded most frequently at *Plectrachne* dominated sites, which are favoured by this species elsewhere (McKenzie and Youngson 1983). By contrast, another common small dasyurid, the Lesser Hairy-footed Dunnart (*Sminthopsis youngsoni),* was more common on the swales. Both the Fat-tailed Antechinus

(*Pseudantechinus macdonnellensis*) and the Common Planigale (*Planigale maculata*) were observed entering holes in termite mounds which are likely to be important habitat components, especially for *P. macdonnellensis* (McKenzie and Youngson 1983).

Although their tracks and droppings were recorded at most sites, camels were rarely seen and their impact on the local environment was apparently minimal since little evidence of browsing or overgrazing was noticed. Cat and fox densities were generally low. Despite 5–10 hours spotlighting on each trip the only feral predator observed was a cat 20 km from Nifty on the Woodie Woodie road. However, cat, fox and dingo tracks were recorded at several monitoring sites (Table 2) and frequency of recording signs of foxes and cats increased during the survey period. Signs of foxes and cats were also recorded respectively from 7 and 4 of 15 predator transects in the Nifty region in November 1996 (Paltridge 1997). These observations concur with those of Algar and Sinagra (1997) that feral predator numbers had increased following recent heavy rains. The remains of Bilby, Desert Banded Snake, Spinifex Hopping Mouse, House Mouse, goanna and dragon have been recorded from cat stomach contents or faeces collected from Nifty whereas local foxes have been recorded preying upon Spinifex Hopping Mouse, Blue-tongue Lizard and invertebrates (Paltridge 1997, Algar and Sinagra 1995,1997)

Bilby tracks, scratchings, scats and holes were most common in run-on areas in swales, predominantly vegetated with *Triodia* and *Melaleuca* (Read and Moseby 1995, Read and Niejalke 1996, Paltridge 1997). This concurs with the findings of a regional survey which concluded that Bilbies were more common in alluvial regions and drainage lines rather than sand plains and dunes (McKenzie and Youngson 1983), probably due to increased moisture and nutrient levels (Southgate 1990). Low sandy mounds around *Melaleuca* shrubs were apparently favoured burrow sites although several Bilby burrows were situated at the base of dunes or between *Triodia* hummocks.

Mulgara burrow systems were located most consistently at site 4B in a *Triodia basedowii* swale which was burnt in 1989. An active warren located 30m from a sand-dune and approximately 150m from an older patch of unburnt spinifex in October 1995 was apparently replaced with another 140m away in March 1996 then usurped again by a warren between these two in November 1996. Warrens had one to three main entrances (60mm diameter) to the burrow system with associated spoil heaps, one to six smaller entrances (50mm diameter) and one or two pop-holes, all within a 5m diameter. The *Triodia* formed tight clumps averaging 30cm in diameter at about 50% cover. These findings are consistent with some previous studies on Mulgara habitat which suggest a habitat preference for recently burnt spinifex of 20–80% cover (L. Baker, pers. comm.),

although Masters (1993) found that Mulgaras were more common on old spinifex, compared to recently burnt areas.

Three marsupial moles have been recorded at Nifty since 1994; one as a roadkill, one disturbed during drilling operations, and one drowned in floodwaters from the Cyclone Kirsty rains in March 1996. All three were probably the recently described Northern Marsupial Mole (*N. caurinus*), although only one specimen was lodged with the Western Australian Museum. *Notoryctes caurinus* is believed to be parapatric with *N. typhlops*. Despite extensive searches for its distinctive tracks no further signs of this elusive fossorial mammal have been located near the Nifty mine.

Amphibians

Five species of frog inhabit the Nifty region despite the absence of permanent water bodies. *Notaden nichollsi* is clearly the most abundant and widespread frog species in the region (Table 2), as it is in the eastern Simpson Desert (Predavec and Dickman 1993), and is one of the most common vertebrates at Nifty. Distinct age cohorts could not be detected from the SVL measurements of *N. nichollsi*, which ranged from 6 to 48 mm (Read and Niejalke 1996). There may be some form of commensualism between *N. nichollsi* and the undescribed species of *Uperoleia* which has affinities to *Uperoleia* aff. *russelli*, since these taxa, or closely related forms, are regularly excavated from the same burrows by Aboriginal women in the Tanami Desert (R. Paltridge pers comm.). *Neobatrachus aquilonius* and *Cyclorana maini* were mainly restricted to larger swamps. With the exception of a single specimen from a deep pond near site 1, *Litoria rubella* was restricted to the permanent water at Nifty camp and sewer ponds.

Birds

Ninety-one species of birds have been recorded from the area (Table 3). Zebra Finches were clearly the most abundant and widespread bird during the surveys and numbers peaked near the mine (Table 3), probably due to the permanent supply of water there. Galahs were also very abundant and concentrated around waterpoints and a favoured roost amongst Coolibahs at site 2. Other consistently widespread and abundant birds included Singing Honeyeaters, Grey-headed Honeyeaters, Pied Honeyeaters, Yellow-throated Miners, Budgerigars, Diamond Doves, Red-browed Pardalotes, White-winged Fairy-wrens, Variegated Fairy-wrens and Black-faced Woodswallows. Crimson Chats were abundant in most surveys but were rare in October 1995. Black and Brown Honeyeaters were common in the October and November surveys, whilst White-fronted Honeyeaters were only abundant in the March 1996 survey. The diversity of raptors at Nifty is notable with 12 species recorded, yet the Nankeen Kestrel was the only regularly recorded species.

Both Grey and Peregrine Falcons are rare and possibly threatened

through much of their ranges and Wedge-tailed Eagles and Rufous-crowned Emu-wrens are regionally uncommon (Start and Fuller 1983). The Bush Stone-curlew and Australian Bustard have declined historically and are recognised as being of national conservation significance (Garnett 1992)

Mining Impacts

House mice (*Mus musculus*) were common on the rehabilitating waste dumps despite being rare at other sites. Apparently *M. musculus* did not outcompete *P. hermannsburgensis* which was as common on the rehabilitation sites as control sites. *Mus musculus* predation has been linked with reductions in small skink numbers elsewhere (Newman 1994), and may have been responsible for the slow colonisation of rehabilitation sites by skinks. Several other species such as *Sminthopsis youngsoni, Varanus brevicauda and Ctenotus quattuordecimlineatus* were also trapped more frequently at rehabilitated sites and hence may be favoured by the conditions there. Gould's Goannas were regularly recorded in the Nifty camp and three *Ctenophorus nuchalis* were observed in close proximity to the mine, while none were found in undisturbed habitats in the region. Bradshaw (1981) also recorded a population of *C. nuchalis* at Shark Bay which was restricted to a disturbed, man-made environment and replaced by congeners in undisturbed habitats.

A suite of species including Magpie-larks, White-backed Swallows, Fairy Martins, Zebra Finches, Diamond Doves and Budgerigars were more common near mine and camp waterbodies than at control sites (Table 3) and hence have probably benefited from the project-related water supplies. Richard's Pipits benefited from the open spaces on the waste-rock dumps. By contrast, Horsfield's Bronze Cuckoo and songlarks were recorded in low numbers at control sites but not near the mine. Low population sizes preclude verification of whether these species avoided disturbed regions or whether their distribution was a stochastic artefact of low densities.

Twenty-six waterfowl species have now been recorded at Nifty. Waterfowl activity was centred upon the artificial Lake Nifty, the Nifty camp sewer ponds and the desalination plant water ponds. Grey Teal have bred on Lake Nifty (Read & Moseby 1995). Migratory waders, presumably moving across Australia *en route* from the south-east Australian coastline to the Broome region, and large flocks of granivorous finches, parrots and pigeons, also utilise water bodies in the Nifty region. A total of 30 bird deaths associated with utilisation of the toxic pregnant liquor ponds were recorded from November 1994 until March 1997. Clean water bodies are valuable in minimising the likelihood of serious avifauna problems associated with birds drinking or alighting upon toxic water bodies (pers. obs.).

Of the 574 *N. nichollsi* inspected following 265mm of rainfall associated from Cyclone Kirsty in

Table 3. Bird records from Nifty Copper Operations until December 1996. Names and name sequence follows Christidis and Boles (1994).

	Sites						Total	No. of sites
	1	2	3	4	5	Mine		
Emu (*Dromaius novaehollandiae*)	+						0	3
Black Swan (*Cygnus atratus*)							0	1
Australian Wood Duck (*Chenonetta jubata*)							0	1
Pacific Black Duck (*Anas superciliosa*)						+	0	1
Grey Teal (*A. gracilis*)		4				6	10	4
Pink-eared Duck (*Malacorhynchus membranaceus*)						2	2	1
Hardhead (*Aythya australis*)						+	0	1
Hoary-headed Grebe (*Poliocephalus poliocephalus*)						6	6	3
Australasian Grebe (*Tachybaptus novaehollandiae*)		1				5	6	3
Little Black Cormorant (*Phalacrocorax sulcirostris*)							0	1
Australian Pelican (*Pelecanus conspicillatus*)							0	1
White-faced Heron (*Ardea novaehollandiae*)						+	0	5
White-necked Heron (*A. pacifica*)							0	1
Black-breasted Buzzard (*Hamirostra melanosternon*)							0	1
Black Kite (*Milvus migrans*)				1			1	1
Whistling Kite (*Haliastur sphenurus*)		+					0	1
Spotted Harrier (*Circus assimilis*)			1			+	1	6
Brown Goshawk (*Accipiter fasciatus*)		1					1	1
Wedge-tailed Eagle (*Aquila audax*)						+	0	1
Little Eagle (*Hieraaetus morphnoides*)	1			+			1	3
Brown Falcon (*Falco berigora*)			1	1		1	3	6
Australian Hobby (*F. longipennis*)						3	3	4
Grey Falcon (*F. hypoleucos*)							0	1
Peregrine Falcon (*F. peregrinus*)	1						1	1
Nankeen Kestrel (*F. cenchroides*)	2			1	2	5	10	12
Baillon's Crake (*Porzana pusilla*)							0	1
Spotted Crake (*P. fluminea*)						+	0	1
Black-tailed Native-hen (*Gallinula ventralis*)						+	0	2

Eurasian Coot (*Fulica atra*)						26	26	3
Australian Bustard (*Ardeotis australis*)	1		+		+	+	1	11
Little Button-quail (*Turnix velox*)	1	+	+		+		1	6
Common Sandpiper (*Tringa hypoleucos*)						4	4	4
Common Greenshank (*T. nebularia*)						+	0	2
Bush Stone-curlew (*Burhinus grallarius*)						+	0	1
Black-winged Stilt (*Himantopus himantopus*)						17	17	3
Red-necked Avocet (*Recurvirostra novaehollandiae*)						+	0	1
Red-capped Plover (*Charadrius ruficapillus*)						+	0	1
Black-fronted Dotterel (*Charadrius melanops*)		+				+	0	3
Red-kneed Dotterel (*Erythrogonys cinctus*)		+					0	1
Banded Lapwing (*Vanellus tricolor*)							0	1
Australian Pratincole (*Stiltia isabella*)		+					0	1
Gull-billed Tern (*S. nilotica*)							0	1
Sooty Tern (*S. fuscata*)						+	0	1
White-winged Black Tern (*S. leucopterus*)		+				+	0	2
Common Bronzewing (*Phaps chalcoptera*)							0	1
Crested Pigeon (*Ocyphaps lophotes*)	3						3	2
Diamond Dove (*Geopelia cuneata*)	15	11	13	11	8	3	61	14
Galah (*Cacatua roseicapilla*)	4	89	24	10		151	278	15
Little Corella (*C. sanguinea*)							0	1
Cockatiel (*Nymphicus hollandicus*)						+	0	4
Budgerigar (*Melopsittacus undulatus*)	19	108	32	64	6	18	247	15
Pallid Cuckoo (*Cuculus pallidus*)						1	1	1
Horsfield's Bronze-Cuckoo (*C. basalis*)		+		3			3	4
Barn Owl (*Tyto alba*)						+	0	2
Tawny Frogmouth (*Podargus strigoides*)						+	0	2
Spotted Nightjar (*Eurostopodus argus*)	+	+				+	0	5
Australian Owlet Nightjar (*Aegotheles cristatus*)	+						0	1
Fork-tailed Swift (*Apus pacificus*)		+	20	18			38	3
Red-backed Kingfisher (*Todiramphus pyrrhopygia*)	4	2	2		1	1	10	13
Sacred Kingfisher (*T. sancta*)							0	1
Rainbow Bee-eater (*Merops ornatus*)	+		+	10		+	10	5
Variegated Fairy-wren (*Malurus lamberti*)	6		33	5	17	10	71	13

Table 3 (cont.)

	Sites						Total	No. of sites
	1	2	3	4	5	Mine		
White-winged Fairy-wren (*M. leucopterus*)	10		48	7	37	15	117	14
Rufous-crowned Emu-wren (*Stipiturus ruficeps*)	3				3	+	6	3
Red-browed Pardalote (*Pardalotus rubricatus*)	5	2	8	4		2	21	14
Spiny-cheeked Honeyeater (*Acanthagenys rufogularis*)						1	1	1
Yellow-throated Miner (*Manorina flavigula*)	18	5	3	1		12	39	15
Singing Honeyeater (*Lichenostomus virescens*)	11	5	29	25	9	14	93	19
Grey-headed Honeyeater (*L. keartlandi*)	62	71	8		5	2	148	15
Brown Honeyeater (*Lichmera indistincta*)	20	5	8			+	33	8
White-fronted Honeyeater (*Phylidonyris albifrons*)		1	4	3	1	1	10	6
Black Honeyeater (*Certhionix niger*)	10	16	9			11	46	6
Pied Honeyeater (*C. variegatus*)	3	18	8	24	17		70	11
Crimson Chat (*Ephthianura tricolor*)	3	27	16	43	9	3	101	15
Magpie-lark (*Grallina cyanoleuca*)						3	3	5
Willie Wagtail (*Rhipidura leucophrys*)			1			+	1	4
Spangled Drongo (*Dicrurus hottentottus*)							0	1
Black-faced Cuckoo-shrike (*Coracina novaehollandiae*)	5	2	+			+	7	9
White-winged Triller (*Lalage sueurii*)	3						3	3
Masked Woodswallow (*Artamus personatus*)			2		2	+	4	4
Black-faced Woodswallow (*A. cinereus*)	5	16	5	8	7	12	53	15
Little Crow (*Corvus bennetti*)		1					1	2
Torresian Crow (*C. orru*)		1	1			1	3	3
Richard's Pipit (*Anthus novaeseelandiae*)						9	9	6
Zebra Finch (*Poephila guttata*)	22	63	124	32	132	228	601	20
Painted Firetail (*Emblema picta*)	1		4	13	14	6	38	5
White-backed Swallow (*Cheramoeca leucosternum*)	1	2	14			13	30	9
Fairy Martin (*Cecropis ariel*)		2	6			+	8	5
Spinifexbird (*Eremiornis carteri*)	1		1				2	3
Rufous Songlark (*Cinclorhamphus mathewsi*)		+					0	1
Brown Songlark (*C. cruralis*)				+			0	1

March 1996, 29 (5.1%) abnormalities were detected. Sample sizes for the other frog species were not sufficient to calculate meaningful abnormality frequencies although these preliminary data suggest similar rates amongst other species (Read and Niejalke 1996). None of the 48 *N. nichollsi* collected from the rehabilitation sites or pools in the immediate vicinity of the mine exhibited any visible skeletal abnormalities. Most (21) of the abnormalities recorded were shortening, hooking or bifurcation of the distal elements of a single digit and recurring abnormalities on the right foot or left hand may indicate a genetic aberration, rather than a deformity caused by environmental insults.

DISCUSSION

The Nifty area supports a reptile assemblage which rivals the world's most diverse described reptile assemblages (Pianka 1986), along with a diverse assemblage of mammals and birds which include several rare and threatened species. The persistence of such a diverse fauna assemblage is probably at least partly attributable to the paucity of exotic mammals, particularly rabbits, and the absence of pastoral influences in the region.

The decline and extinction of many Australian medium-sized mammals has also been partially attributed to changes in the burning regimes of desert regions (Morton 1990). Traditional owners used patch burning techniques to flush game and promote new vegetation growth. These practises resulted in a mosaic of vegetation patches of varying sizes and ages. Such a mosaic increased diversity of plants and animal assemblages and enabled some animals to move and take advantage of resources as they became successionally available within a burnt area (Masters 1993; 1996, James 1994). However, since Aboriginal displacement, many spinifex deserts have reverted largely to more uniform regions of similar age and successional stage which are not suitable for several species and prone to large scale, destructive bushfires. The vegetation cover at Nifty exceeds 35% cover in many localities, which is denser than optimum Bilby habitat (Paltridge 1997) and fire also promotes growth of important Bilby food plants (Southgate 1990). Fire management, based upon traditional patch burning, in conjunction with CALM scientists is being implemented to increase the productivity of the spinifex and improve the local habitats for threatened mammal species, particularly Mulgaras and Bilbies.

Further survey work should reveal an even richer herpetofauna and avifauna than reported here. Two small skinks, *Morethia ruficauda* and *Lerista vermicularis* which have been recorded nearby at Telfer (Hart, Simpson and Associates 1991) also potentially inhabit the Nifty region. The fossorial lizard guild at Nifty is particularly interesting. Sympatric trapping of *Lerista ips, L. bipes* and *L. xanthura* along with

Eremiascincus. fasciolatus at site 3D provides an opportunity to test the thesis of Henle (1989) that fossorial guilds of reptiles are only stable if all species are morphologically and ecologically well separated.

Grey Falcons are a rare and threatened species nationally (Garnett 1992) and were not recorded on a series of bird surveys of the Great Sandy Desert (Start and Fuller 1983). Hence the Nifty record of an injured individual which was sent to Perth for rehabilitation is particularly significant. The Wedge-tailed Eagle record is locally significant since this species has become rare in the region, presumably due to the decline in medium-sized prey species (Storr 1981). The persistence of Wedge-tailed Eagles in the region may therefore be dependent on the maintenance of the Bilby and populations of other medium-sized mammals.

Frog abnormality rates recorded from remote control sites in the Nifty region were higher than that recorded from undisturbed sites elsewhere in the Australian arid zone (Tyler 1989, Read & Tyler 1990, Read & Tyler 1994) but lower than from an undisturbed locality in Western Australia (Roberts 1985). Since higher levels were detected at remote sites than sites in the immediate vicinity of mining operations, these data suggest that the mining operation has not had a deleterious impact on local frog communities. The 1996 survey therefore provides a useful baseline for studies measuring the extent and degree of any future impacts of NCO on the local frog populations.

In conclusion, the Nifty region supports a diverse faunal community including several taxa of conservation and scientific interest. Potential deleterious impacts of the mine and processing plant, including land disturbance and contamination, mortality of avifauna attracted to toxic ponds and increases in feral animals attracted to food and shelter resources, appear to be well managed to date, with negligible pervasive impacts on the regional environment. Continued advances in rehabilitation techniques, persistent dump maintenance, feral animal control programmes and deterrence of waterfowl from toxic waterbodies should ensure that impacts to the local wildlife is minimal through the life of the mine. Indeed, collection of monitoring and research data on plant and animal responses to mining, rehabilitation and seasonal conditions, along with a proactive controlled patch-burning policy, could enhance both the scientific knowledge and ecosystem functioning of this remote and poorly studied region.

ACKNOWLEDGEMENTS

This survey would not have been possible without the assistance of several talented and dedicated personnel. Mark Robertson (NCO) assisted with field work, compilation of historic data and most importantly, collection of additional data between surveys. Katherine Moseby, Darren

Niejalke and Rachel Paltridge assisted with field work, interpretation of results and report preparation. Peter Kendrick (CALM) and John Angus conducted an additional trapping session which added considerably to the dataset. Terry Reardon (SA Museum) identified bat sonagraphs and Laurie Smith, Ken Aplin and Norah Cooper from the WA Museum identified or verified collected specimens. John Dell provided useful comment on a draft of this document.

This work was supported by WMC Resources Ltd. with special thanks to Sean Kildare for establishing the monitoring program and to Olympic Dam Corporation, Mark Robertson and Shelley Innes for continued assistance, Nifty Copper Operation and WMC Corporate Relations for financial and logistical assistance. CALM granted permission to conduct the surveys and provided additional information on feral predators and fire management.

REFERENCES

ALGAR, D. and SINAGRA, J. A. 1995. The control of feral cats at Nifty Copper Operations. Department of Conservation and Land Management, Wanneroo.

ALGAR, D. and SINAGRA, J. A. 1997. Feral Cats: Nifty Copper Operations. Department of Conservation and Land Management, Wanneroo.

BRADSHAW, S. D. 1981. Ecophysiology of Australian desert lizards: studies on the genus *Amphibolurus*. *In: Ecological biogeography of Australia* (Ed A. Keast) pp 1395–1434. Dr W. Junk, The Hague.

CHRISTIDIS, L. and BOLES, W. E. 1994. The taxonomy and species of birds of Australia and its territories. *Royal Australasian Ornithologists Union Monograph 2.* RAOU, Melbourne.

CANN, J. 1978. *Tortoises of Australia.* Angus and Robertson.

GARNETT, S. T. 1992. Threatened and extinct birds of Australia. RAOU Report 82. Royal Australasian Ornithologists Union and Australian National Parks and Wildlife Service, Melbourne.

HART, SIMPSON and ASSOCIATES Pty. Ltd 1991. Telfer to Big Tree area, fauna survey. Newcrest Mining Limited.

HART, SIMPSON and ASSOCIATES Pty Ltd 1992. Nifty Project. Environmental appraisal and management. Unpubl. Report WMC Engineering Services Pty Ltd, Perth.

HENLE, K. 1989. Ecological segregation in a subterranean reptile assemblage in arid Australia. *Amphibia-Reptilia* 10: 277–295.

JAMES, C. D. 1994. Spatial and temporal variation in structure of a diverse lizard assemblage in arid Australia. Ch 13. *In: Lizard Ecology: Historical and Experimental Perspectives* (Eds. Vitt, L. J. and Pianka, E. R.). Princeton University Press, Princeton, New Jersey.

MASTERS, P. 1993. The effects of

fire-driven succession and rainfall on small mammals in spinifex grassland at Uluru National Park, Northern Territory. *Wildl. Res.* 20: 803–13.

MASTERS, P. 1996. The effects of fire-driven succession on reptiles in spinifex grasslands at Uluru National Park, Northern Territory. *Wildl. Res.* 23:39–48.

MAXWELL, S., BURBIDGE, A. A, and MORRIS, K. 1996. *The 1996 action plan for Australian Marsupials and Monotremes* (Draft). IUCN Species Survival Commision.

McKENZIE N. L. and YOUNGSON, W. K. 1983. Mammals. Part 3 *In*: Wildlife of the Great Sandy Desert. Eds: Burbidge, A. A. and McKenzie, N. L. *Wildl. Res. Bull. West. Aust.* 12: 62–93.

MORTON, S. R. 1990. The impact of European settlement on the vertebrate animals of arid Australia: a conceptual model. *Proc. Ecol. Soc. Aust.* 16: 201–13.

NEWMAN, D. G. 1994. Effects of a mouse, *Mus musculus*, eradication programme and habitat change on lizard populations of Mana Island, New Zealand, with special reference to McGregor's skink, *Cyclodina macgregori*. *N. Z. J .Zool.* 21: 443–456.

NIFTY COPPER OPERATIONS 1995. *Triennial Environmental Report 1992–1995.* Unpubl. Report, WMC Resources (Nifty Copper Operations), Nifty, Western Australia

PALTRIDGE, R. 1997. *Bilbies and predators at Nifty, W.A.* Unpubl. Report. WMC Resources (Nifty Copper Operations), Nifty, Western Australia

PIANKA, E. R. 1986. *Ecology and Natural History of Desert Lizards.* Princeton University Press, New Jersey.

PREDAVEC, M. and DICKMAN, C. R. 1993. Ecology of desert frogs: a study from southwestern Queensland. pp 159–169. *In*: *Herpetology in Australia, a Diverse Discipline* (Eds Lunney, D. and Ayers, D.). Roy. Zool. Soc. NSW, Sydney.

READ, J. 1994. *Fauna survey of the Nifty Region.* Unpubl. report, WMC Resources (Nifty Copper Operations), Nifty, Western Australia.

READ, J. and MOSEBY, K. 1995. *Fauna survey of the Nifty Region II.* Unpubl. report, WMC Resources (Nifty Copper Operations), Nifty, Western Australia.

READ, J. and NIEJALKE, D. 1996. *Fauna survey of the Nifty Region III.* Unpubl. report, WMC Resources (Nifty Copper Operations), Nifty, Western Australia.

READ, J. L. and TYLER, M. J. 1990. The nature and incidence of post-axial, skeletal abnormalities in the frog *Neobatrachus centralis* Parker at Olympic Dam, South Australia. *Trans. R. Soc. S. Aust.* 144: 213–217.

READ, J. L. and TYLER, M. J. 1994. Natural levels of abnormalities in the Trilling Frog (*Neobatrachus centralis*) at the Olympic Dam mine. *Bull. Environ. Contam. Toxicol.* 53: 25–31.

RICHARDS, G. C. and HALL, L. S. 1996. *Draft Action Plan for*

Australian bats. Report to Environment Australia, Canberra.

ROBERTS, J. D. 1985. Population estimates for *Arenophryne rotunda*: is the Round Frog rare? In: *Biology of Australian frogs and reptiles* (Eds. G. Grigg, R. Shine and H. Ehmann), Royal Zoological Society of New South Wales, Sydney.

SOUTHGATE, R. 1990. Habitat and diet of the Greater Bilby *Macrotis lagotis* Reid (Marsupialia: Peramelidae). in: *Bandicoots and Bilbies* (Eds. J. Seebeck, P. Brown, R. Wallis and C. Kemper), Surrey Beatty, Sydney.

START, A. N. and FULLER, P. J. 1983. Birds. Part 4 in: Wildlife of the Great Sandy Desert. (Eds. Burbridge, A. A. and McKenzie, N. L). *Widl. Res. Bull. West. Aust.* 12: 94–108

STORR, G. M. 1981. Birds of the north-eastern interior of Western Australia. *Rec. West Aust Mus.* 9: 65–99.

TYLER, M. J. 1989. *Australian Frogs.* Viking O'Neil, Chipping Norton, Victoria.